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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR
C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS
J. S. PLASKETT
Director of the Dominion Astrophysical Observatory, Victoria, B.C.

J. PATTERSON
Director of the Meteorological Service of Canada, Toronto

R. MELDRUM STEWART
Director of the Dominion Observatory, Ottawa

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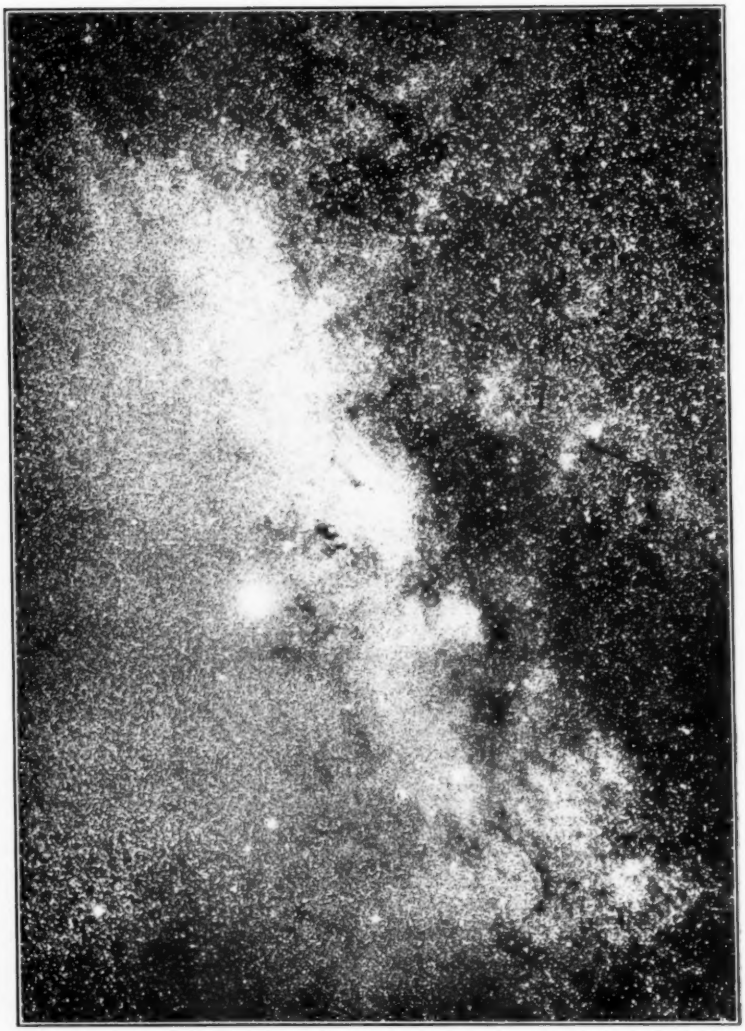
PLATE XXVIII
North



Plaque Lumière Opta

THE MILKY WAY, CONSTELLATION AQUILA
Photograph by M. de Kerolyr
Scale 10 mm. = 2°.8

Journal of the Royal Astronomical Society of Canada, 1929

PLATE XXIX

North

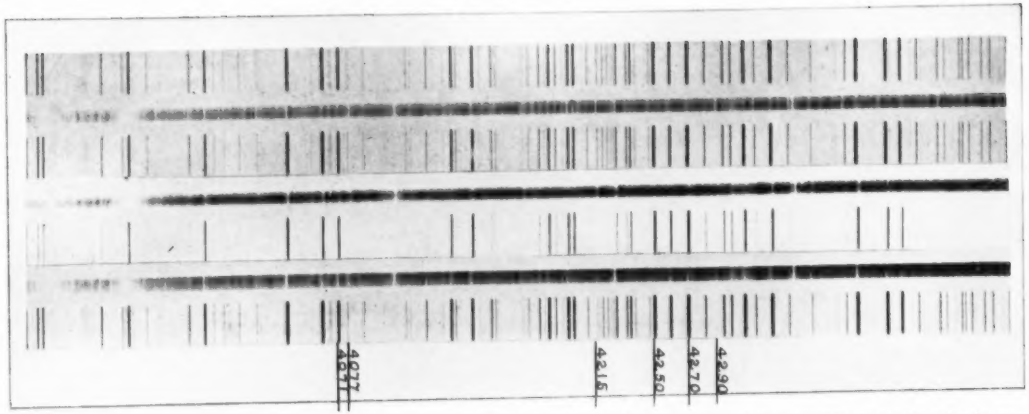
Plaque Lumière Opta

ENLARGED PORTION OF PLATE XXVIII

Scale 10 mm. = 29'

Plates XXVIII and XXIX are photographs of a portion of the sky showing the dark nebula near Gamma Aquilae. They were taken by M. de Kerolyr in September, 1929, as described in the September number of this JOURNAL. The bright star in the lower left hand corner of plate XXIX is Altair. On plate XXVIII the same star is 1.4 inches from left edge and 2.5 inches from the bottom.

PLATE XXX



Spectra of three stars showing absolute magnitude effect. The narrow bands are the stellar spectra, the wider bands are comparison spectra. Top spectrum, Polaris (Alpha Ursae Min.); middle, Gamma Persei; bottom, Zeta Ursae Majoris. Note the strength of 4077, 4215 and 4209 in Polaris as compared with 4070, 4250 and 4270, respectively. Compare the same lines in the bottom spectrum. Polaris is a giant; Zeta Ursae Majoris a dwarf star.

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EXPLORING SPACE[1]

By W. E. HARPER

In this address my aim will be to describe methods used by astronomers to obtain the distances of the heavenly bodies and then, using the results to date, to give a bird's eye view of the stellar universe.

A measuring rod must be chosen suitable to our needs. A foot rule would serve to measure this room; a steel tape would be more suitable for a city block and a 100-foot chain more appropriate still for large stretches of country. Each measuring rod should be based eventually upon the smallest, which must be one easily recovered and constant.

Now the wave-length of light, about 1/40,000 of an inch, seems about as small a quantity as likely ever to be needed and upon it is based the international standard of length—the metre bar, deposited in a certain vault in Paris. With this metre as the unit of measurement, a portion of the earth's surface has been accurately measured and through astronomical observation the whole circumference, and hence the diameter, is related to our metre standard. The earth's equatorial diameter is 7926.68 miles and this distance may be designated our inch measure if you please.

How do we start to measure the distances to the heavenly bodies? A year or so ago there was considerable talk about the feasibility of shooting a projectile to the moon but until we experience a joy ride of that thrilling nature, with a tape reeling out

[1]Adapted from an address given before the Royal Astronomical Society of Canada.

behind us, we had better have recourse to saner and more scientific methods of finding the moon's distance.

Let us take a leaf out of the field surveyor's book, and see how he obtains distances which cannot be chained off directly. If there is an inaccessible mountain peak (C in Fig. 1) he will measure off

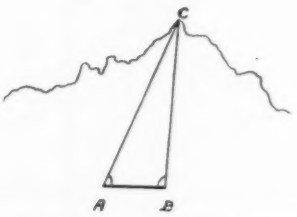

Fig. 1. Determining the distance of a mountain peak.

a base-line (AB) near by, half a mile or so in length, appropriate to the distance of the peak. Setting up his theodolite at each end of the base he measures the angles between the base and the peak. He thus has a triangle whose base and angles at the base are known and a knowledge of ratios, or trigonometry as it is called, enables him with a moment's calculation to get the distance to the peak. Mt. Everest has never been scaled, yet its distance from Darjeeling is accurately known.

Suppose we apply this *trigonometrical* method to get the distance to the moon. Observers at Greenwich and Capetown, say, agree to observe the moon at the same instant. (Fig. 2). From observa-

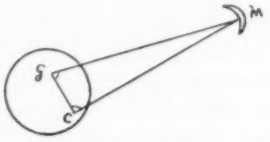

Fig. 2. Determining the distance of the moon.

tions of its altitude at the two places they can determine the angles at the base of the triangle Greenwich—Cape Town—Moon. The

base-line G C being known, the distance of the moon is found to be about 30 times the earth's diameter or, approximately, 239,000 miles.

Could we use this method to obtain the sun's distance? Yes, even though it is 400 times as great, if only it were not such a glaring object. It is impossible to set upon it as accurately as upon a point image like a star, and as the sun's distance is our next higher unit of length used in measuring the distances to the stars it is essential to have it determined as accurately as possible. Any error in its determination affects the scale of the whole universe.

Two methods of determining its distance will be merely outlined. The planet Venus, which revolves about the sun in 225 days, on

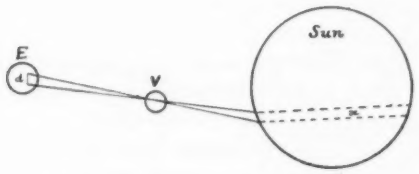

Fig. 3. Determining the sun's distance by a transit of Venus. Dotted lines represent apparent paths across the disc for different stations on the earth. Not drawn to scale.

rare occasions comes directly between us and the sun, at which times it appears as a black dot crossing the disk. In 1882 such a transit occurred and observers, north and south, traced its apparent path across the sun's disk (Fig. 3). The distance between these apparent paths could be related to the distance between the observers on the earth and thus the whole diameter of the sun was obtainable. It was then a simple problem to calculate how far away that diameter of 864,100 miles must be to appear as half a degree in angular measure. As, however, the next favourable transit does not occur until June 8, 2004, we pass this method by for a better one.

Besides the eight main planets there are a number of little planets, or asteroids as they are called, that also circle the sun. One of these, Eros by name, perhaps 15 miles in diameter, is very useful for our purpose. Its year is 1 3/4 times our own and on

rare occasions it comes close to the earth. At such times we can determine its absolute distance, exactly as we did that of the moon. Moreover, we know from the periods of revolution its distance from the central sun relative to our own, and, now that we have obtained the distance of the asteroid, a brief calculation suffices to deduce our distance from the sun. These favourable oppositions are rare and, worse luck, one occurred just four years before the asteroid was discovered in 1898. However, in 1931 a very favourable opportunity will again present itself and already plans are under way for concerted action. By the various methods in vogue the agreement has been found to be extremely close and the accepted value of 92,870,000 miles will not be materially changed in future

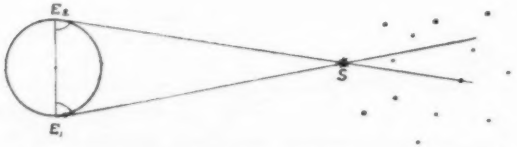

Fig. 4. Determining the distance of a star. The diameter of the earth's orbit about the sun, $E_1 E_2$, 186,000,000 miles, is used as the base.

work. This is our second fundamental unit of measurement and can be styled the foot-rule if you wish

It is this foot-rule that is used in measuring the distances to the stars. How do we do it? We simply carry on as the surveyor has started us, using the longer base line just determined. If we require the distance of some particular star we note its position (From E_1 in Fig. 4) in the sky with reference to the fainter and presumably much more distant stars in the background. Six months later, when we have been carried around to the other side of the sun at E_2 and are 186,000,000 miles distant from our present position in space, we again note its position. We thus have a triangle with known base and base angles which we can solve and get the star's distance. While such an operation seems very simple in theory, it is very difficult in practice. The stars are so remote that our base line of 186,000,000 miles, though it seems enormous to our human way of thinking, is exceedingly minute

compared with the distances to the stars. If we imagine ourselves located on the closest star yet discovered this base line would appear no longer than a one-inch stick held at a distance of 2 1/4 miles.

Small wonder is it then that no such measures had been made until comparatively recent times when instruments of extreme precision were available. The first astronomer to plan such a systematic investigation was Herschel in 1782. He reasoned somewhat in this manner On the average bright stars are closer to us than faint ones and if there should chance to be two such dissimilar stars close to one another in our l ne of sight, though likely infinitely remote from each other, then throughout the year as we swing around the sun there should be a perceptible variation in their relative positions. Let me in a crude way exemplify this idea right in this room. Assume that I am the earth moving about the sun a few feet distant. Near the front of the room is a bright star; almost in line, but near the rear is a faint one. I note the direction of each on the distant wall. Six months later when on the other side of the sun I again note their positions and find that the faint star near the wall has changed its position very, very slightly but the nearer one a great deal.

This is what Herschel expected to find as he set out to study these so-called double stars. What he actually did find in many cases was quite different; that they were changing their positions not yearly but in long periods of time, the two slowly revolving about each other. It is said of old of Saul of Isreal that he set out to seek his father's asses and found a kingdom instead. Herschel set out to seek one truth and found a greater kingdom of truth—namely, that the laws of gravitation were operative not only in the solar system but outside as well.

The interest attached to the movements of these binary stars was such as to overshadow for half a century the original problem of getting the distances of the stars, or parallaxes as they are called. The parallax is simply the angle which the 93 million-mile base would subtend at the star and naturally is smaller the farther away the star (Fig. 5). About 1838 Bessel obtained the parallax of the binary star 61 Cygni, one of our near neighbours in space. Up to the beginning of the present century the parallaxes of only a score

or so of the nearest stars had been determined. Naturally the nearest ones, showing the largest angles for measurement, were selected first. How can one guess the stars which are likely to be close?

On the average the brighter stars will be closer than the fainter. But there is an even better method of guessing. While the stars are spoken of as fixed, they are only so in the sense that the eye cannot detect changes of position, even after the lapse of centuries. Precise measurements, however, show that all the stars are in motion, to or from us and hither and thither across our line of vision. These latter *cross* motions, which are determined in angular measure would, if they were very large, suggest nearness of the

Fig. 5. The parallax of a star is the angle subtended at the star by the distance earth to sun.

objects concerned and these large "proper motion" stars were the ones first investigated.

Moreover, the early observations were entirely visual but early in the century the photographic method was standardized and adopted. Photographs of a star field, taken six months apart under identical conditions, will serve from the changed relative positions of the stars on the plate to differentiate those which are near from those which are distant, whilst precise measures enable us to deduce definite parallaxes. About the year 1908 half a dozen large observatories entered into a co-operative scheme to obtain trustworthy parallaxes by this method and the list of several hundred stars in our *Handbook* is largely the result of that splendid co-operation.

But there is a limit to the distances which can be successfully deduced by this trigonometrical method. The nearest star has a parallax of 0.76 seconds of arc, which is the angular measure our 93 million-mile foot-rule would show at the distance of that star.

So perfect have measuring engines become, though, that a star probably 19 times as far away—that is one subtending an angle only 1/19 as great—can be determined with reasonable precision. Farther out than that the method becomes unsatisfactory as the errors of measurement are comparable to the quantities we are seeking to determine.

How many such stars, then, are amenable to this method? We cannot say with any degree of certainty, but assuming that within a reasonable distance of our solar system they are uniformly distributed we can make a fair guess. There are 17 stars known to be within a parallax of 0″.25 and if we assume this density holds out to a parallax of 0″.04, which a moment ago was accepted as our working limit, then the corresponding volume of space should contain 4,364 stars. Probably less than one-third of these would be visible to the naked eye.

These stars have, under the cooperative scheme, been pretty well completed and it would seem as if we were about at the end of our tether. But necessity is the mother of invention and barely had we reached our limit by one method when a new and more powerful method of attack, based upon the old, was developed. It was in this way. One star may appear to us brighter than another and yet if the two stars were at exactly the same distance from us the apparently fainter might be actually the brighter. For the few hundred stars, whose distances had thus been determined by the surveyor's extended method, it was possible to calculate their relative luminosities if they were all supposed to be at the same standard distance. These are spoken of as their real or absolute luminosities. It was rather surprising to find a great range of brightness shown, some being 100 times as luminous as our sun and some 100 times as faint. Thus about the year 1911 originated the names "giants" and "dwarfs" as applied to the stars.

Three years later the discovery that concerns our particular problem was made. It was found on comparing the analysed light, or spectrum as it is called, of one of these giants with the spectrum of a dwarf that there were marked differences between the two. Certain spectral lines in the giant were abnormally strong whilst in the dwarfs these same lines were very weak (Plate XXX). Since this feature was common to all the giants, with the dwarfs con-

sistently showing the opposite effect, it was possible by a mere inspection of a star's spectrum to say whether it was a giant or a dwarf. Moreover, when refined measures of the intensities were made it was seen that there was a gradual change from the strong lines of giants to the faint ones of dwarfs. A linear relationship was thus established between the intensities of certain spectral lines and the absolute luminosity of the star producing the same (Fig. 6). So that just as little things in people reveal their depth of character or the opposite, these little lines were sensitive criteria of the actual luminosity of a star. It was thus possible by taking a spectrum

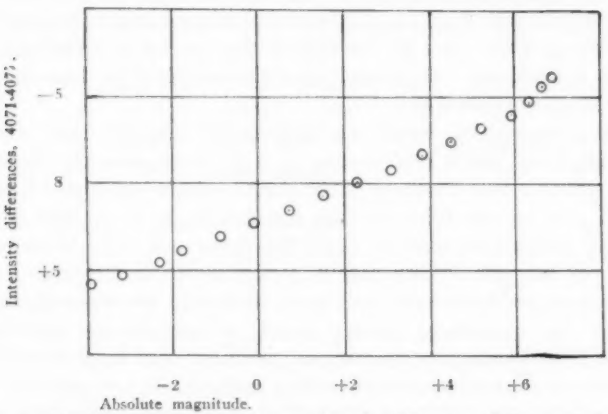

Fig. 6. Showing the relationship between intensity differences of lines and the absolute luminosity of a star.

of a star whose distance was desired and examining these tell-tale lines to learn its absolute luminosity.

Well, what has that to do with distance, you say? The connection may not be very evident at first but if we remember that the amount of light received varies inversely as the square of the distance, we will realize that knowing its real brightness we can easily compute how far away it must be to appear of the brightness as seen in the sky.

Thus from a limited number of stars of known distance we deduce relationships which enable us to go out unlimited distances.

The only restriction that is imposed upon us is that the star must be apparently bright enough to record these tell-tale lines with a reasonable exposure time.

The marvellous increase in our knowledge of stellar distances during the past few years has been due in large measure to these criteria of line intensities and these "spectroscopic parallaxes" as they are called now number well up into the thousands. The method originated at the Mount Wilson observatory just prior to the war but since then the work has been taken up and prosecuted with vigour at several other observatories. Utilizing certain spectra of our own observatory, Dr. Young, a former colleague, and the writer discovered some new lines, which possibly strengthened the method, and issued in 1924 a list of 1105 stars with parallaxes based upon this method. Similar lists have come from other observatories. Thus whereas in 1900 we knew the distances of only a few score stars; in 1910 of a few hundred; now we have several thousand.

But once again certain circumstances seemed to set a limit to the method and circumscribe its usefulness. Only a certain class of stars, the comparatively cooler ones, showed the lines which were sensitive to brightness. The hotter stars, technically known as the O-, B- and A-types and constituting about thirty per cent. of the total number, had very few lines in their spectra and at that time none of these had shown any indications of revealing the secrets of the stars from which they came. As far as could be judged by the small *cross* motions of these stars they were at great distances from us and highly luminous, and what evidence there was seemed to indicate that they were fairly uniform in brightness. We know now that while the range in luminosity of those stars showing line variations—the so-called late-type stars—is more than 10,000 to 1, in these hotter stars it is not over 100 to 1, thereby making the problem of securing sensitive criteria seem exceedingly hopeless.

But just when things seemed stalled in one direction another way of escape opened up. Hitherto spectroscopic results had been purely empirical, that is, they were obtained by simply noting arbitrary differences in the spectra of giants and dwarfs. There was no knowledge as to why certain lines behaved one way in one star and in a different way in another star. But physicists who

had been studying how the vibrating atom produces a spectral line came nobly to the rescue and showed that the lines were behaving just as they ought to behave in these giants and dwarfs. An atom, they said, may be likened to a miniature solar system with a massive central nucleus, positively charged, around which circulate a number of tiny negatively charged electrons. In both classes of stars the atom is badly knocked about but in the giants in particular, because of their exceeding tenuity and corresponding low pressure, the atom is apt to lose one of its outer electrons—to become *ionized* as we call it. Normally, the strontium atom has 38 of these electrons surrounding it but in the rarefied atmosphere of a giant star a large proportion of these atoms lose an outer electron and the spectral lines which are produced by the strontium atom in this condition become of corresponding great intensity. The line numbered 4077 in Plate XXX is one of those due to strontium in this ionized state, and, as may be seen from the upper spectrum which is that of Polaris, a giant star 625 times as luminous as our own sun, this line is exceptionally strong. Thus it became possible to predict how certain lines should behave in different stellar spectra and so direction was given to the search for new criteria. These are days of close co-operation between the astronomer and the physicist to their mutual advantage.

Similar known facts regarding the sharpness or diffuseness of spectral lines under varying conditions of density and pressure began now to be weighed in the balance in this connection. It was found that in this respect also the behaviour of lines in stellar atmospheres is just what we might expect from their behaviour in the laboratory under the limited range of physical conditions that can be produced there. Under ordinary atmospheric pressure and density, spectral lines have a certain definite width; if you place the light-giving source in a vacuum tube and keep reducing the pressure the lines become narrower and sharper. Conversely by increasing the pressure the lines become wider and more fuzzy. Now in the atmospheres of stars we have as just stated great differences of pressure and density and we might naturally look for corresponding differences in the sharpness of the lines. In giant stars where we have a large volume of matter at a very low density and pressure we might expect sharp lines; in dwarfs where the

atmospheres are crowding in close to the central nucleus, trying to smother it, as it were, we have pressures and densities greatly increased and corresponding breadth, and fuzziness of the spectral lines might be expected. Between the two extremes should be found stars of moderate luminosity and moderate sharpness of lines.

To test the matter out, of course, stars whose real luminosities were known should be examined. While the distances of a very few of these hotter stars had been determined by the direct method yet a number were known from other considerations and a total of about 150 was available for the test. As the computed luminosities of these had a thirty or forty-fold range they were sufficient to test out the idea, and it was found on doing so that there was a gradation in real brightness corresponding to the sharpness of the lines. Sharp lines are indicative of great luminosity, fuzzy lines of lesser luminosity. It must be borne in mind that the range of differences was not large but nevertheless the general tendency was shown to be as expected, and thus an empirical relation was established connecting the two quantities. In other words a curve could be drawn relating sharpness with brightness so that for an unknown star, by noting the sharpness of its lines, we could establish its real luminosity and then deduce its distance.

By taking the spectra of 544 A-type stars and noting the relative sharpness of their spectral lines the Mount Wilson observers were able to deduce the corresponding parallaxes or distances. This work is only in its initial stages and improvements are bound to come but the basic principle seems sound. Thus by the strength and now by the *sharpness* of spectral lines do we deduce a star's distance.

Let us review our steps and see how far out we have gone and how we have been enabled to do so. Our first unit of measurement was the wave-length of light, approximately 1/40,000 of an inch. Upon it we based the metre standard, a little over 39 inches. Upon that we based the diameter of the earth, roughly 8,000 miles; upon that we based the distance to the sun, 93 million miles; upon that we based all those stars which were near enough to the solar system to allow that small unit of measurement to be of use. This put us out to a distance 10^{15} miles. Then using the stars within this volume of space, which thus became known as to their real or absolute

luminosities, we found relations to exist between such absolute luminosity and the intensity or sharpness of the lines in the corresponding star's spectrum. We were thus enabled to explore space throughout any depth, provided the stars were bright enough to give spectra with reasonable exposure times. But the faintest stars require impossible exposure times and once again we seemed to be up agaist a stone wall.

Nevertheless a method has been found for a certain class of these. Among the stars whose distances were determined by previous methods there are some that are found to vary periodically in light. They rise rapidly to maximum brightness, then slowly fall to minimum. The phenomenon recurs regularly and for each star there is a definite period of time required for the variation—these periods lying approximately between one and one hundred days. Moreover, a relationship was discovered between the period and the mean absolute brightness, so definite that if we know the period we can predict the brightness. We need not concern ourselvez with the reason for this; let us accept it as an observed fact and make it serve our purpose. It is not a serious task to follow the fluctuations in brightness of even the faintest stars; a few minutes will suffice to photograph the star's image when the light has not to be wasted by passing through the prism-spectroscope. Consequently, where any of these Cepheid variables are recognized, we can, by determining the period of their variability, at once deduce their real luminosity and hence their distance.

Let us apply this to some star clusters infinitely remote with respect to anything yet described. In these are found very faint stars which show variations identical with those just now described. Can we safely assume that they are real Cepheid variables and that their apparent faintness is due to their great distance? If so, we can deduce that distance. Let me give a homely illustration. Suppose we are shut in in a deep valley with surrounding mountains, some near, some distant. We wish to determine the distances of the far away peaks. Around us in the valley grow luxuriant ferns, possibly three feet in height, whilst on the neighbouring slopes rise stately fir trees a couple of hundred feet in height. Through our telescope we examine the distant peaks and see them covered with vegetation which reminds us first of the ferns beside us, but

which on second thought we recognize as fir trees similar to those on the nearby slopes. Knowing from the specimens close at hand their average height, and assuming that that average height is maintained as far as we can see, we can from the angular size of the vegetation deduce its distance. But what an awful mistake we would have made and how much closer would we have brought the peaks had we mistaken fir trees for ferns.

So, too, in the depths of space. If we can be sure that those variables, which look like Cepheids and act like Cepheids, are in all respects such as exist in our own immediate region of space, then we can deduce from their extreme apparent faintness how remote they are. Since gravitation and many other phenomena have been found to be common throughout space we no longer hesitate to accept uniformity of design in another direction. That being the case, the distances of some 70 globular clusters are known and will be given presently.

Before doing so and presenting a plan of the universe it is again necessary to give you a more convenient unit of measurement. It is the 'light-year', the distance that light will travel in one year going at its determined rate of 186,000 miles per second. Such a velocity carries it in one second between seven and eight times around the earth. It will flash from the sun to us, 93,000,000 miles, in a little over eight minutes. In one year it travels 6×10^{12} miles and that distance may be thought of as our "yard stick".

Starting at the sun and imagining ourselves moving outward with that great velocity we come in three minutes to Mercury, in six minutes to Venus, in a little over eight minutes to the earth and continuing on outwards past Mars, Jupiter, Saturn and Uranus we come at last to Neptune in 4½ hours. That is to say, light flashes across the radius of the solar system in 4½ hours. How much longer would we have to travel before we reached the nearest star? A journey not of hours but of years awaits us, light requiring 4½ years to come to us from the nearest stellar system. Off in another direction is the next closest neighbour of our solar system and light requires about 6 years to cross the intervening space. There are only 6 stars within 10 light years, so we are not crowded in the immediate vicinity of our own solar system.

Are the stars spread uniformly throughout space? By looking

closely at the heavens on a clear night we see a faint band of light circling the sky which from childhood we have known as the Milky Way. This milkiness is due to the fact that the stars extend to greater distances in this direction than in one at right angles to it and the myriads of faint distant stars blend their light to form the suffused glow so aptly called the Milky Way. The general form in which the stars are assembled in space may be thought of not as a sphere, in which distances in all directions from the centre would be the same, but rather like a flattened discoid, as if two dinner plates were placed face to face. The long diameter, then, corresponds to the Milky Way regions, where we see through the greatest depths. This diameter is estimated to be about 300,000 light-years in length, that is to say, light would require that great stretch of time to flash from one side of the stellar universe to the other. The shorter diameter is probably less than one-tenth as great.

Now our solar system lies fairly well in the central plane of the Milky Way though not exactly at the centre. The globular clusters referred to lie in the central plane of the Galaxy but to one side of our solar system and at varying distances, the nearest being Omega Centauri, 21,000 light years, and the most remote N.G.C. 7006, 230,000 light years.

From the southern skies are seen a pair of nebulous patches in the sky known as the Greater and Lesser Magellanic Clouds. Shapley has determined the distances of the Lesser Cloud to be 102,000 light years away.

But even these distances, unreal as at first mention they seem to the lay mind, pale into insignificance with those obtained by similar methods for what are known in the heavens as spiral nebulae. These objects, apparently like fuzzy stars, when studied on large scale photographs, are found to contain starlike condensations which simulate variability like our tell-tale Cepheid stars. Going on that assumption Hubble has determined for N.G.C. 6822 the enormous distance of *one million light years.*

SIR ISAAC NEWTON'S LIBRARY OFFERED FOR SALE IN ENGLAND

By James Stokley

The library of Sir Isaac Newton, greatest of English-speaking scientists, is now for sale in London and British men of science are wondering what its ultimate fate may be. Will it cross the Atlantic to the United States, as so many of England's literary treasures have done in recent years, or will it find an appropriate resting place in the Royal Society's library or at Newton's alma mater, Trinity College, Cambridge? Though no definite price has been set so far, it is not likely that the books will be sold for less than $100,000. The present owner will only sell the library as a complete unit, so there is no danger of it being scattered.

Until the recent discovery of these books by Col. R. de Villamil, the whereabouts of Newton's library was a mystery of many years standing. Because of his outstanding eminence in the late seventeenth and early eighteenth centuries, it was obvious that Newton must have had a large library, but none of the biographies mentioned it. Until 1920 it was thought that the library had completely vanished.

In that year an old mansion at Thame Park, in Oxfordshire, was sold at auction by the owner, a Mr. Wykeham-Musgrave, who owned another home at Barnsley Park, in Gloucestershire. To this sale were sent a lot of old books from the latter house. The books were not known to be of any particular value, and were sold as rubbish, even though a few bore the autograph "Js. Newton". The entire lot went for about $500. A few of the purchasers discovered that they had books from Newton's library, these were eventually sold in London by a large dealer in old scientific works, but a considerable number of the books were sent to the pulp mill and irretrievably lost. Of those sold, many were bought for American libraries. Many brought prices as high as several hundred dollars, and one, the copy of Euclid that Newton used as a student at Cambridge, was listed at $3,000.

In 1927, at the time of the tercentenary of Newton's death,

Col. de Villamil wrote an account of "The Tragedy of Sir Isaac Newton's Library" in *The Bookman*. This came to the attention of Mr. Wykeham-Musgrave, who finally invited Col. de Villamil to visit his Barnsley Park home to see a few books that still remained. He had previously discovered a catalogue of the library, made about 1760, showing that it had contained 1896 books.

"I went," he told a Science Service representative, "expecting to see, probably, 15 or 20 books, but found I could count at least 300 or 400, and I guessed that there might be 600. I have catalogued them, and have actually found 860, which, out of 1896, is more than what one would call a residue."

All these books had been stuck away in cupboards and corners where their owner did not even know of their existence, otherwise they would probably have been sold at Thame Park and lost.

Col. de Villamil has now worked out the complete history of the library. After Newton's death it was sold to his neighbor, John Huggins, warden of the Fleet Prison. He gave the books to his son, Charles Huggins, rector of Chinnor. When he died about 1750, his successor, Dr. James Musgrave, bought it from the estate for 400 pounds, and pasted his own bookplate in the books, over the Huggins bookplate. The Musgrave plate consisted of his arms combined with the Huggins arms, for he had married Charles Huggins' niece. Underneath was the Latin motto, "Philosophemur". This bookplate is still in the books, together with the numbers Dr. Musgrave put in them when he catalogued the library about 1760. It is this catalogue that Col. de Villamil found.

Dr. Musgrave died in 1778 and the library passed to his son, who took it to Barnsley Park. There it was recatalogued, and renumbered. Though the original owner was then recognized, the Newton tradition was finally forgotten, and they were stuck away as old books of no particular value. There they remained until discovered by Col. de Villamil.

Science Service,
Washington, D.C.

THE DETERIORATION OF SILVERED GLASS MIRRORS AND THE REFLECTING POWER OF POLISHED CHROMIUM STEEL

By R. K. Young and Mrs. V. Krotkov

The efficiency of a reflecting telescope depends upon the state of the silvered mirror. The glass must be resilvered at intervals which may vary from a month to a year, depending upon the climate in which the telescope is used and the quality of the silver coat. In a smoky city, where the air is charged with dust and chemicals, the mirror will tarnish very quickly, while in a clear dry air free from impurities it may last for a year or more.

Silvering small mirrors is a simple matter but the labour is much greater for larger sizes. In an observatory where the observers and astronomers do their own silvering, the task is often, under the pressure of work, deferred for some time after it should have been done. The present measures were made to correlate the change in appearance of the mirror with the reflecting power, in order that the observer might be able to tell to some degree how much loss of light there was.

In table I, columns 2 and 3, is given the reflecting power of silver on glass, as taken from the *International Critical Tables* and from values given by Langley. The latter were taken from a paper published by H. D. Curtis[1].

Table I

λ	International Critical Tables	Langley	No. 1 New	No. 4 New	No. 1 Old	Chromium
8000	96.3%	%	%	%	%	%
7000	94.6			93		
6000	92.6	93	90	89	86	69
5000	91.3	89	80	82	75	69
4500	90.5	85	74	78	63	68
4000	83.6	79	60	65	50	65
3500	67.5	61				

We may assume that these measures were made on very good silver coats. Nevertheless they differ by more than 6 per cent. at λ3500. Apparently a silver coat may look first class and yet be considerably less effective than possible. We made many trials

[1] "Methods of Silvering Mirrors" by H. D. Curtis, *A.S.P.*, Vol. 23, 1911.

of silvering small mirrors (3 in. × 3 in.), mostly by the Brashear process, but several also by the Rochelle salts method[1]. In no case did we obtain a surface giving as high a reflecting power as those given. Columns 4 and 5 give the results of our two best mirrors when a few days old. It is quite possible that when freshly deposited, the surface was more reflecting in the violet. Both these mirrors looked first class, giving the sun a deep blue colour when viewed by transmitted light and the sky light without any tinge of yellow when viewed by reflected light. Our experience has been that a reflecting power at λ4000 which is greater than 65 per cent. is difficult to obtain.

The reflecting powers of the various mirrors were measured from time to time as the silver coat tarnished and notes made of the appearance to the naked eye. No attempt was made to reburnish the silver but it was wiped off lightly with absorbent cotton to remove any dust.

The method of measuring the reflecting power was briefly as follows. A small automobile light, 12 volt, 24 c.p., was aged and supplied with current from a storage battery, the current being held, by a resistance, constant to within 1/100 of an ampere. Usually no adjustment of the rheostat was necessary and the position of the needle of the ammeter stayed constant even when viewed with a magnifying glass giving 10 diameters' magnification. The current probably varied in most cases less than this amount. The light illuminated a diffusing screen about 1½ inches in diameter so placed as to flood the collimating lens of a small spectrograph, the collimation always being carefully checked. The mirror whose reflecting power was to be measured could be introduced between the diffusing screen and the slit of the spectrograph and alternate exposures given to a photographic plate for direct and reflected light. As many as fifteen to twenty exposures could be made on one plate. The densities of the images were measured at various wave lengths, by a wedge method, and curves drawn giving the darkening for various exposures to direct light. It was comparatively easy to find the exposure necessary with the reflector to reproduce the same density as any given exposure to direct light. Sensitometer squares were imprinted on many of the plates for the various emulsions used, in order to determine the correction

[1] *Ibid*, Vol. 23, p. 17.

necessary to transfer these equivalent exposure times into reflecting power. The method was much more complicated than it might have been had a thermo-couple been available, but it served very well and we think the final values, which depend on the means of many exposures, should be accurate to one per cent. or so.

Column 6 of the table shows the measured reflecting power of mirror No. 1 after about forty days. The mirror was kept in a drawer in the Physics' Building of the University, which is adjacent to the Chemical Building. The surface tarnished quite rapidly. In another location the same ageing might not take place for a year. The age should be judged by its appearance. The following notes were made prior to making the determinations in columns 4 and 6.

When the mirror was fresh, the filament of an electric light bulk could be faintly seen through a single coat. The filament, which had a reddish tinge without the mirror, upon being interposed, looked bluish white through the mirror. Reflected skylight looked a deep blue. The sun could be seen through two coats of the silver without any irradiation and looked distinctly blue. Direct sunlight through a single coat gave a small amount of irradiation. Before the measures in column 6 were made the mirror looked slightly yellow, and sky light, reflected and direct, could be distinguished. There were one or two little spots on the silver surface. It would have been considered in fair condition.

The result of the measures showed that the reflecting power in the violet had fallen very considerably and it led us to the conclusion that, when the silver coat begins to look a little yellow, the reflecting power in the red and yellow part of the spectrum was not much impaired while the reflecting power at wave length 4000 to 3900 was not over 50 per cent.

Column 7 gives the measured reflecting power of a small mirror made from polished chromium steel kindly sent us by Mr. J. W. Fecker, of Pittsburgh, Pa. This mirror was in excellent condition when it reached us and looked as bright as a silver-on-glass mirror and of a rather bluish tinge. The measures showed that at wave length 4000 it equalled our best silver mirror. At the time of writing this note, when the mirror is about eighteen months old it looks like new, while the silver mirror No. 1 is now quite black and useless. For small amateur reflecting telescopes, where the weight of a small mirror is of no consequence, polished chromium or chromium steel should prove superior and more convenient than glass.

METEORITES OF IOWA

By C. C. Wylie

In works on meteors and meteorites the state of Iowa is mentioned as especially favoured, for four of the most important meteoric falls recorded in modern times have occurred within its boundaries. This record is probably due in part to the zeal of certain men in Iowa who were much interested in meteors, and made a study of the bright ones in the state for about a generation after the Civil War. Professor Olivier, President of the American Meteor Society, estimates that only about one in ten of those reaching the earth is recovered. It is possible that the record for Iowa means merely that a larger per cent. have been recovered

The first recorded fall occurred on February 25, 1847, when a meteor dropped stones about nine miles south of Marion The next was on the evening of February 12, 1875, when a very brilliant meteor, with earth-shaking detonations, dropped meteorites on the Amana settlement in Iowa county. More than 800 pounds of meteoric material was recovered. On the afternoon of May 10, 1879, another great meteor fell, this time in full daylight bursting near Estherville. The largest meteorite recovered at this fall weighed more than 400 pounds. It is the largest in America for which we know the date and circumstances of fall. The last meteoric fall was near Forest City on the afternoon of May 2, 1890. It is probable that since that date other meteorites have fallen within the boundaries of the state, but if any have been recovered they have not been submitted to experts for examination, so are not included in the catalogues. Among possible meteoric falls since that date the following might be mentioned.

On June 2, 1891, what was supposed to be a meteoric stone fell near Alta, Iowa, and was reported by Mr. David E. Hadden, local amateur astronomer. On March 27, 1894 according to Professor G. D. Hinrichs, meteoric material fell near Marengo, Iowa. On May 31, 1917, Mr. Hadden observed in the west a brilliant detonating meteor; the detonations reaching him at Alta five minutes after the flash of light. This meant that it must have been a large

meteor bursting at a low altitude. Hence, the chance of meteorites having reached the surface of the earth at that time appears good. Another large detonating meteor burst over northwestern Iowa on the evening of April 6, 1927, and numerous reports were received by the Weather Bureau and the State University.

Recent Meteors of Iowa and Illinois

The meteor of January 2, 1927, was first noticed at a height of a little more than eighty miles over a point about twenty-five miles north of Waterloo, passed nearly over Cedar Rapids, and over a point about five miles west of Iowa City, crossed the Mississippi river a few miles north of Burlington, and burst and disappeared at a height of about seventeen miles over a point in Illinois some fifteen miles southeast of Burlington. This meteor fell at 6.02 p.m., an hour when many people were outdoors driving or doing chores on the farm; therefore numerous reports were received from the states of Iowa, Minnesota, Wisconsin, Illinois, and Missouri. It was bright enough to light up the countryside in pronounced fashion like "a flash of green lightning," except that it lasted longer, or like a revolving airmail light. Many people who were out driving wrote that their first impression was that the lights of another car had been suddenly turned on them. If this meteor dropped any meteoric stones, calculation shows that they fell a few miles north and west of Macomb, Illinois.

On July 13, 1927, at about 1.00 p.m., a brilliant meteor fell near Tilden, Illinois, with detonations like loud thunder. A young man who saw it from a distance of more than one hundred miles reported that it looked like "a piece falling off the sun." At a height of fifteen or twenty miles it burst showing green and then purple, and after a second bursting became invisible. The smaller pieces, after bursting, had their velocities very quickly reduced to a point where they were no longer luminous in driving through the dense lower atmosphere. One stone, weighing nine pounds, fell in the village of Tilden, and was glimpsed for an instant as "a dark streak, like smoke" by some who were watching after the "blasts" of the detonations. It was recovered at once, and to the surprise of the finders was not hot, but cold, "noticeably cold." A larger one,

weighing forty-six pounds, was recovered by boys who saw dust fly where it struck in a clover field. A smaller piece, weighing a fraction of a pound, was picked up on a lawn in Sparta, while the largest recovered, one hundred and ten pounds, was found only after the present writer had arrived to direct the search in person. This meteorite, now at the State University of Iowa, ranks with the largest in the world for which the circumstances of fall are known and preserved reasonably intact. The Tilden fall is the only one recorded in Illinois where meteorites are known to have been recovered.

On July 25, 1929, at 9.46 p.m., the most brilliant meteor recorded at night in the middle west for many years fell in Illinois. It was first noticed over a point near Champaign, Illinois, and at a height of something more than one hundred miles. It burst and disappeared at a height of between twenty and twenty-five miles near De Kalb, Illinois. Perhaps in reality it was not as bright as the Tilden meteor, but, falling at a convenient hour in the early evening, it attracted attention at a distance of more than five hundred miles. Several hundred letters were received by persons in astronomical and meteorological work. The State University received numerous letters directly, and in addition the letters received by the Weather Bureau and at Drake University were forwarded. This gave information from the states of Illinois, Indiana, Iowa, Michigan, Missouri, Minnesota, Nebraska, Wisconsin, and South Dakota. With clear weather it should have been seen as far in other directions as it was reported to the west and northwest. This means that it was, with proper weather conditions, visible also in Alabama, Arkansas, Canada, Georgia, Kansas, Kentucky, Maryland, Mississippi, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Tennessee, Virginia, and West Virginia. It lighted up nearly a million square miles of territory, a remarkable record.

The Midwest Meteor Association

This is an informal organization of persons interested in meteor work, with headquarters at Iowa City. If a member sees a bright meteor, or hears of another person seeing one, he sends what in-

formation he can to headquarters, and requests for information are then sent to all members. Each member sends what information he can obtain from observations in his own community. Several members also assist in observing the August and November meteors, which are merely "shooting stars," but quite numerous. The August meteors were observed this year from seven stations in eastern Iowa, and weather permitting, similar observations are planned for November. At Iowa City, on the best night, 223 meteors were recorded between the hours of 12.00 and 2.30. In return for their services, members receive from time to time reports giving the results obtained from this co-operative work on meteors. College and high school teachers and students, and other persons interested should address *The Midwest Meteor Association*, Iowa City, Iowa.

University of Iowa,
Iowa City.

TERRESTRIAL MAGNETISM*

By W. W. Campbell

If I were asked to name and describe the most wonderful fact known to man, my reply would be:

So far as our observations and experiences go, every particle of matter in the physical universe is endowed with the property and necessity of obeying the fundamental laws of nature. Our universe of stars, our own star and our earth in all its parts, have been developed through long ages, to their present states, under the guidance and compulsion of perfectly definite and apparently simple laws. We have no reason to suppose that these laws are ever set aside, or varied in the slightest degree. The operations of those laws are believed to be never capricious or undependable. In fact, the arbitrary and the capricious do not seem to exist in physical nature. Whether the arbitrary and capricious exist in human nature is quite another matter, but that is a bridge we need not cross to-day.

This earth of ours, when measured in astronomic units of length and mass, is a mere bagatelle, a negligible thing; but when measured in terms of human dimensions this earth is a perfectly enormous body.

Cutting a little notch in the Culebra ridge at Panama, a ridge only three or four hundred feet high, to let the ships pass through —that was a huge undertaking. Not all the developed wealth of the entire United States would suffice to level off a few small mountain peaks at the edge of Lake Tahoe, and use the resulting materials to fill the cavity now occupied by the waters of that lake!

This great planet of ours is still responding, in major degrees, to the forces, to the laws, which controlled its evolution. There is nothing of greater importance to the well-being of the human race than that its universities and its other research institutions should

*An address given at the celebration of the twenty-fifth anniversary of research in the Carnegie Institution of Washington, on board the non-magnetic ship *Carnegie* in San Francisco Harbor, August 26, 1929.—Printed in *Science*.

determine the nature and the potency of those forces and the ways of those laws, so that the plans of man for doing the work of the world may be in harmony with them, and not in opposition thereto. Our engineers could compel the rapidly descending waters of a mountain stream to reverse their direction and go up hill, through pipes, to their source, but at what a heavy cost, day and night, day and night, and all to no good purpose. The same engineers could harness that stream and make its descending waters generate electricity and, by doing the work of the community, day and night, day and night, contribute to the comfort and happiness of men, women and children.

Now it took the people of this earth a very long time to learn a little something about electricity and chemistry and biology; and scores upon scores of able investigators are still finding out new things about those subjects; not really new things, not new laws and new principles, but old ones, immensely older than the hills, which had not yet been discovered—not yet uncovered—and brought to their notice and comprehension, and ours.

There are forces acting upon the earth whose effects are undoubtedly of great significance, but whose origin and laws are as yet very imperfectly known. I here refer especially to the subjects of terrestrial magnetism and terrestrial electricity. As this little pamphlet, recently issued by the Carnegie Institution, says:

> There exists about the earth a field of magnetic forces of which the origin is still unknown. The distributions and variations of this field present characteristics which are related not only to the magnetic and electric phenomena of the earth and its atmosphere, but also to solar and cosmic phenomena. The strength and direction of the earth's magnetism in the horizontal and vertical planes are referred to as the magnetic "elements," and these vary from place to place.
>
> An exact knowledge of the way in which they vary is demanded for the efficient use of the compass in maritime and aerial navigation; and a study of irregularities of distribution is one of the few means we possess for investigating the properties of subterranean masses. However, the values of the magnetic elements obtained at any point are not constant, but undergo periodic and irregular variations.

There is a diurnal variation in the pointing, a gradual shifting of the needle back and forth in a period of twenty-four hours, this diurnal shifting being greatest in summer and least in winter—obviously an effect, direct or indirect, of the sun's heat. There is

another shifting of the needle, back and forth, in an average period of eleven years plus, which evidently bears intimate relation with the periodicity of the spots on the sun. Further, there is a long-period or secular change in the pointing of the needle. At the Greenwich Observatory, in southeastern London, the magnetic needle in the year 1570, when the long series of magnetic observations was begun, pointed 11° east of north; in 1660, ninety years later, its pointing was due north; in 1800 it pointed 24° west of north—a change of 35° in 230 years. Since 1800 the needle's pointing has been shifting easterly, until at Greenwich to-day the average reading is about 14° west of north.

Then there are two principal types of sudden fluctuations of the needle pointings:

First, those due to special conditions called "magnetic storms," which in their more intense forms are usually accompanied by aurorae, by electric currents of cosmic origin on our telegraph and telephone lines which for a few hours may prevent our use of them, and by especially active or large or numerous spots on the sun; and

Secondly, those due to the near presence of magnetic materials in the earth. In 1922, as the ship on which we were passengers was approaching the harbor of Broome, on the northwest coast of Australia, and through the courtesy of the captain on the bridge, we watched the ship's compass needle vary its pointing through 70° and back again in the course of not more than three or four minutes of time. We were apparently passing nearly over a great subterranean mass of metallic iron ore, or other materials possessing magnetic properties.

Now these extraordinary magnetic happenings had long been studied, but almost exclusively by individuals working alone, and on land areas forming but a minute part of the earth's surface. This problem of terrestrial magnetism, relating to the whole of the great planet upon which we reside, is accordingly an extremely extensive, complicated and difficult one. The first step toward its solution consists in the acquiring of the facts; the making of millions of accurate observations of the magnetic elements upon the surface of the continents and the seas, and of the electrical elements in the

depths of the waters and in the heights of the air. To complicate the subject, observations already made, no matter when, do not continue to fit their points of observation: the magnetic elements at any point of observation vary with the passing of time, as already explained. The problem is entirely too large for an individual; it is a problem for an institution, a continuing institution, of great financial resource.

We have heard anew, on this anniversary occasion, about the establishing of the Department of Terrestrial Magnetism in the Carnegie Institution of Washington, under the leadership of Dr. Bauer, in 1904, with definite purpose and commendable courage, to take up the study of this problem; and we have learned to-day about the good ships *Galilee* and *Carnegie*—something of their extensive cruises, back and forth, upon the seas, and just a little about the well-planned and well-executed activities of their staffs. The observations secured upon their decks have been supplemented, simultaneously, by similar observations made at thousands of land stations on all the continents except Antarctica. The very great number of accurate observations secured on land and sea and in the air and water have priceless value for the human race. The results thus far obtained from the study of these observations, results recognized by all students of the subjects as of very great importance, are but the first fruits of the heroic undertaking.

The commercial ships which are traversing the seas and making the whole world kin have during nearly two decades past been guided by charts whose magnetic elements are remarkably accurate, thanks to the work of the ship *Carnegie*. The staff of this ship upon which we are assembled discovered on its first cruises that the earlier charts used by the navigators were in error by astonishing amounts—approximately a degree as to the pointings of the compass in some parts of the intensively used north Atlantic trade route, and even as much as four, five and six degrees on some of the Pacific Ocean routes.

The extensive observations and the remarkable deductions on the subject of atmospheric electricity made by the department can scarcely fail to be of tremendous importance in the domain of radio transmission.

Professor Emanuelli's tables for the conversion of equatorial co-ordinates into galactic co-ordinates are the most extensive yet published. The argument in declination is given for every degree and in right ascension it is given for every 10^m. The body of the table is given to tenths of degrees. While it is not strictly necessary to publish all quadrants and declinations from +90 to −90, this has been done, and it makes the tables very convenient in use and lessens the danger of making mistakes. Tables at the bottom of the pages give the variations for one minute of right ascension so that interpolation can be made with a little effort mentally. Near the pole of the galaxy where the table becomes uncertain it is supplemented by a subsidiary table giving the arguments for closer intervals.

The position of the galactic pole adopted is R.A. $12^h\ 44^m$, Decl. +26°.8, and the origin of galactic longitudes determined to make the galactic longitude of the solar apex zero. The solar apex is taken as R.A. 270°, Decl. +30°. The origin of the longitudes differs from the decision reached at the International Astronomical Union in Cambridge, 1925, where it was proposed to base the zero longitude on α Cygni, a star of small proper motion. However, this is not of much consequence as a simple correction, which is given, enables a change to other origins of longitude to be made.

The tables are well arranged and printed in clear type and should serve all purposes. They are much to be preferred to a series of graphs, being easier and more accurate to use.

R.K.Y.

Considerations sur sept Cepheides, by G. Tiercy. Osservazioni e Memorie del R. Osservatorio Astrofisico di Arcetri, Fascicolo N. 45.

It is well known that for each star, the radius R, the absolute magnitude M, the temperature T and the colour index I are not independent of each other.

On the other hand the colour index I is a function of the star's spectral class and thus of the state of ionization which exists in its reversing layer. This state of ionization varies both with the temperature T and with the pressure P.

In the case of Cepheid variables considered as pulsating stars

it is interesting to investigate what empirical relations exist between these various quantities. If such empirical relations are obtained for a few Cepheids it is very likely that they apply to all of them.

The study of all the known characteristics of the seven Cepheid variables *SU* Cassiopeiae, *T* Vulpeculae, *W* Sagittarii, *S* Sagittae, *Y* Ophiuchi and *X* Cygni led to three main curves for a main spectral class which give:

(*a*) The mean radius when the mean colour index is known.
(*b*) The mean absolute magnitude when the mean colour index is known.
(*c*) The mean colour index when the period is known.

It is also led to three other curves which give the relations at the particular epoch when the star is of spectral class F5:

(*a*) Between the actual colour index and the mean colour index.
(*b*) Between the actual radius and the mean colour index.
(*c*) Between the actual absolute magnitude and the mean colour index.

Similar curves could be obtained for epochs when the star is of any other spectral class.

F. HENROTEAU.

Astronomie allgemeinverständlich dargestellt von V. V. Stratonov. Translated from the Russian manuscript by M. Chovanec and edited by A. Prey. 292 illustrations and 55 plates, in colour and in black-and-white. Prag: B. Koci; Leipzig: Brockhaus. 6×9½ inches, 20 parts at 1.20 Rm each, 1929.

This is a popular illustrated work on astronomy by a well-known astronomer in the Moscow state university. It will be completed in about 20 parts of 32 pages each. It was prepared at the request of the Russian government, and before being issued by the state was translated into German. Its publication recalls that of Ball's "Story of the Heavens" a generation ago and of "The Splendour of the Heavens" more recently. The present writer hopes it may have a wide circulation.

C. A. C.

The Universe Around Us, by Sir James Jeans. 352 pages, 5½×8½ in., 24 plates and 24 text-figures. Cambridge University Press, 1929. Price, 12*s.* 6*d.*

to the earliest attempts of the ancient astronomers to reconcile our incommensurable natural units of time. This last is by Dr. J. K. Fotheringham, Reader in Ancient Astronomy and Chronology in the University of Oxford.

The credit for the introduction of these changes and additions to the Almanac is given by the Superintendent to the Deputy Superintendent, Dr. L. J. Comrie.

L. B. STEWART

NEWS AND COMMENTS

At the recent meeting of the American Astronomical Society at Ottawa officers were elected as follows:—R. G. Aitken, Vice-President, 1929-31; R. S. Dugan, re-elected Secretary, 1929-30; Benjamin Boss, re-elected Treasurer, 1929-30; E. S. King and F. H. Seares, Councillors, 1929-32; S. A. Mitchell, member of the Division of Physical Sciences, U.S. National Research Council, 1930-33. The next meeting of the Society will be held at Harvard College Observatory, in December.

Professor Asaph Hall for many years astronomer at the U.S. Naval Observatory, has recently retired. He is making his home at Upper Darby, Pennsylvania, where he is actively continuing certain work, using instruments at the Flower Observatory. (*Science*).

Dr. William Wallace Campbell, president of the University of California and Director of the Lick Observatory, who recently announced his purpose of retiring from the active service of the university in July, 1930, by which time he will have reached the retirement age, was tendered by the academic senate at its meeting on October 7, an appreciative address paying glowing tribute to his genius for organization in the observatory and university.

The new observatory, erected by the University of London, England, at Mill Hill, was opened on October 8 by Sir Frank Dyson, astronomer royal. It possesses a 24-inch reflecting telescope (generously offered to the university by Mr. W. E. Wilson, F.R.S.) housed in an 18-foot dome. There is a spectrographic laboratory with a coelostat and 10-foot Rowland grating spectrograph fed by a 7-inch lens of 12-foot focal length.

The Canadian Geographical Society at its meeting on September 19 in the Victoria Memorial Museum, Ottawa, elected the following Board of Directors:—Hon.-Pres., J. B. Tyrrell; Hon. Vice-Pres., Dr. A P. Coleman; President, Dr. C. Camsell; 1st Vice-Pres., C. G. Cowan; 2nd Vice-Pres., Dr. J. McIntosh Bell; Hon. Treas.,

F. C. T. O'Hara; Hon. Secretary, E. S. Martindale; Executive Committee, President, 2nd Vice-President, Secretary and Treasurer, Prof. D. A. McArthur, Kingston, Dr. S. J. McLean, L. J. Burpee, F C. C. Lynch, Dr. O. D. Skelton, Lieut.-Col. Thos. G. Vien, Dr. J. H. Grisdale. Dr. Grisdale, Chairman of Membership Committee.

There are to be two classes of members, Fellows or Corporate Members, and Members, the fees being four and three dollars respectively. Ordinary membership is open to all. Applications for membership should be addressed to the Secretary, Mr. E. S. Martindale, 238 Sparks Street, Ottawa.

REDeL.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Audibility of the Aurora

P. H. Gosse, in his book, "The Canadian Naturalist", p. 47, (London, 1840), has the following remarks on the possibility of hearing the Aurora Borealis:—"I have never heard any sound accompanying the Aurora Borealis, though I have seen very many, and some very splendid ones; and though I have often eagerly and intently listened; yet I cannot doubt the fact, for I have been assured by persons of undoubted veracity that they have distinctly heard an accompanying sound, though exceeding rarely. Some of these individuals could not be suspected of having taken the idea from books, yet the character of the sound attributed to the Aurora exactly agrees in all the recorded instances in which it has been heard. It was described to me as being like the rustling of a silk flag in a smart breeze. These were all heard in Newfoundland, where it is much more common than in this country (Quebec Province).". . ."If I rightly recollect, Captain Parry records an instance in which he saw a beam of the Aurora Borealis shoot down between him and an opposite hill, not more than a mile or two distant."

Some Practical Uses of Astronomy

From a brief examination of the new *Encyclopedia Britannica* (14th ed.) it would appear that the articles on science have been prepared by able writers. The general editor for astronomy was Prof. A. S. Eddington (although a clerk in the establishment handling the publication in Canada gave the information that Prof. Eddington was responsible for the articles on *astrology*). I take the liberty of quoting one of the introductory sections, which discusses in an interesting way the above subject.

What is the use of astronomy? It is not necessary here to defend the pursuit of pure science whether or not it leads to results which can be used (or, as commonly, misused) for modifying the conditions of human existence. Therefore it is not in any spirit of apology or defence that reference may be made to some of the practical reasons why a study of astronomy is necessary To begin with, it provides the explanation of certain phenomena of immediate importance to us, such as the seasons and the tides. The exact time circulated several times a day by radio is derived from continued astronomical observations. It is of fundamental importance in navigation. Greenwich observatory was founded in 1675 to meet urgent needs of navigation; and in particular its long series of observations of the moon from 1750 onwards has been the basis by which longitudes were determined up to recent times. The radio time-signals have now rendered the moon obsolete for this purpose; but even after 1900 the ownership of many hundreds of square miles of territory hung in the balance until the boundary commissioners were furnished with the latest observations of the moon's position.

All this, it will be said, belongs to the old fashioned type of astronomy, and is no justification of the usefulness of much of the present domain of research which seems to be inspired with the idea of getting as far away as possible from the earth and all terrestrial things. The answer is that scientific knowledge forms a single whole, and if astronomy lags behind, the sister science of physics will suffer. Present-day astronomy has a very definite part to play in the general advance. The stars and diffuse nebulae are physical laboratories where we can watch experiments performed on matter under the most extreme conditions of temperature and density. They supply the gaps in knowledge which the experimental physicist is unable to cover in the limited conditions of a terrestrial laboratory. The element helium, of great practical use to-day, was first discovered in the sun. The theory of relativity has revolutionized the conceptions of physics and is fundamental in our modern knowledge of the atom; but it largely owes its general acceptance to the astronomical tests which were applied. Numerous technical illustrations could be given of the way in which the stars have been invoked to supplement the terrestrial laboratory. At the time of writing (1928) comes the news that the most prominent lines in the spectra of the nebulae are now identified as "forbidden lines" of the spectrum of the oxygen

Under "Notes and Queries" a letter was read giving an interesting observation of the recent fireball seen in Toronto and district. Dr. Chant called the attention of members to Dr. J. H. Jeans' new book, "The Universe Around Us."

The Chairman then called on Dr. C. A. Chant, the lecturer of the evening, the subject announced being "Meteors and Meteorites." He covered the theme in an exhaustive and instructing manner, referring to the connection of fireballs and shooting stars with comets. Dr. Chant stressed particularly the opportunity for amateur astronomers to do some constructive observational work, minute instructions were given for their benefit, demonstrating how the results of their observations should be set down. By ascertaining the speed of these meteors, Dr. Chant stated, we may know something of their origin. If their speed with respect to the sun is less than 26 miles per second we may deduce that they belong to our own solar system; travelling at a greater speed they have, in all probability, come from outer space. Many meteorites are composed of iron and nickle roughly in the proportion of 90% of the former, and 10% of the latter. Many models of meteorites, as well as portions of genuine ones were shown to the audience.

E. J. A. KENNEDY, *Secretary.*

AT VICTORIA

Sept. 18.—The first public meeting of the fall term was held in the Victoria College at 8.00 p.m. In the absence of President J. A. Pearce in Toronto, Dr. C. S. Beals, presided.

The speaker of the evening was Professor A. Pannekoek of the University of Amsterdam, who delivered an address on "Astrology and its influence on Astronomy."

Astronomy went back, said the speaker, to the time when the structure of social life was much different from that at the present time. In its development Babylonian priests, Greek philosophers, mediaeval monks, and noblemen had played their parts. The study of astronomy was a necessity in trade and commerce, in the measurement of time, a guide to travellers, and a guide for the ancient farmers who needed to know when to plant their crops and to harvest them.

The speaker showed how various ceremonies came to be connected with the movements of the planets, and how the ancients began to associate events with the position of the moon and stars. When Greek astrology came into contact with Babylonian astronomy, astrology as a science sprang up. Professor Pannekoek pointed out that astrology was not a regrettable aberration of the human mind but, on the other hand, it was a forerunner of modern astronomy, and the means of raising that science to its present high level. In tracing its history, the speaker showed that Tycho Brahe, the famous Danish astronomer, was the last advocate of the science, and that by his time the desire to discover the connection between men and the universe had been replaced by the desire to discover the laws of the universe itself.

WALTER H. GAGE, *Secretary.*

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(*b*) To publish from time to time the results of the work of the Society; and,

(*c*) To acquire and maintain a Library, and such apparatus and real and personal property as may be necessary and convenient for the carrying into effect of the objects of the Society."

For many years the Toronto organization existed alone, but now the Society is national in extent, having active Centres in Montreal, P.Q.; Ottawa, Ont.; Toronto, Ont.; London, Ont.; Winnipeg, Man.; and Victoria, B.C. Among its 800 members are a number of the leading astronomers and scientists of the world, many amateurs, and in addition, many laymen who are interested in the culture of the science.

Membership in the Society is open to anyone interested in Astronomy. The annual dues are $2.00; life membership $25.00 (no further dues). The annual fee includes subscription to the publications.

The Society publishes a monthly JOURNAL containing about 400 pages of interesting articles, and the yearly HANDBOOK of 72 pages containing valuable information for the amateur observer. Single copies of the JOURNAL or HANDBOOK are 25 cents.

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